Strength Studies of Cement and Crumbed Rubber mixed Fly Ash

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ABSTRACT

Fly ash is a non-plastic, cohesion-less fine grained material. It is highly erodible and needs to be stabilized to remain in place. Making use of the inherent pozzolanic behavior, fly ash can be stabilized easily and economically. Stabilized fly ash has greater resistance to erosion, high strength and relatively impervious.

In the present study experiments were carried out to understand the strength characteristics of stabilized and unstabilized fly ash. Ordinary Portland cement and Crumbed Rubber were used as stabilizers. Different percentages of stabilizers were used for different tests. These percentages are – 6%, 8%, 10%, 12% and crumbed rubber was used 5%.

The results of the unconfined compressive strength (UCS) of Badarpur and Dadri fly ash as affected by the above variables are presented in the report.

Keywords: cement, rubber, flyash, crumbed.

INTRODUCTION

Road network is vital to the economic development, trade and social integration. It facilitates smooth conveyance of both people and goods. Size of the road network, its quality and access has a bearing on transport costs. Besides, road network promote specialization, extend markets and thereby enable exploitation of the economies of scale. Global competition has made the existence of efficient road transport and logistics systems in delivery chain an absolute imperative. Easy accessibility, flexibility of operations, door-to-door service and reliability has earned road transport an increasingly higher share of both passenger and freight traffic vis-à-vis other transport modes. Transport demand in India has been growing rapidly. In recent years this demand has shifted mainly to the advantage of road transport, which carries about 87 per cent and 61 per cent of passenger and freight transport demand arising for land based modes of transport (i.e. roadways and railways taken together) respectively. Road transport has grown despite significant barriers to inter-State freight and passenger movement compared to inland waterways, railways and air which do not face rigorous *enroute* checks/barriers. Given the importance of road network, it is vital to have comprehensive data on road infrastructure to assist in policy planning and investment decisions.

Growth in Road Length

The total road length in India had increased significantly from 3.99 lakh km as on 31.3.1951 to 41.10 lakh km as on 31.3.2008. Concomitantly, the surfaced road had increased from 1.57 lakh km to around 20.36 lakh km over the same period. The increase in road length during 1950-51 through 2007-08 is depicted in Figure 1.

The share of the surfaced road length in the total road length also reflected an improvement. Surfaced road length accounted for 49.5 % of total road length as of 31.3.2008, compared with 39.3% of the total road length as of 31.3.1951.The total road length had expanded significantly since 1970s. It increased from 9.15 lakh km in March 1971 to 41.10 lakh km in March 2008 - an increase of 349 % over these 37 years yielding a compound annual growth rate (CAGR) of 4.1 %. The total road network in the country grew from 36.21 lakh in March 2004 to 41.10 lakh in March 2008 reflecting an increase of 4.89 lakh km yielding a CAGR of 3.2 % over this period.

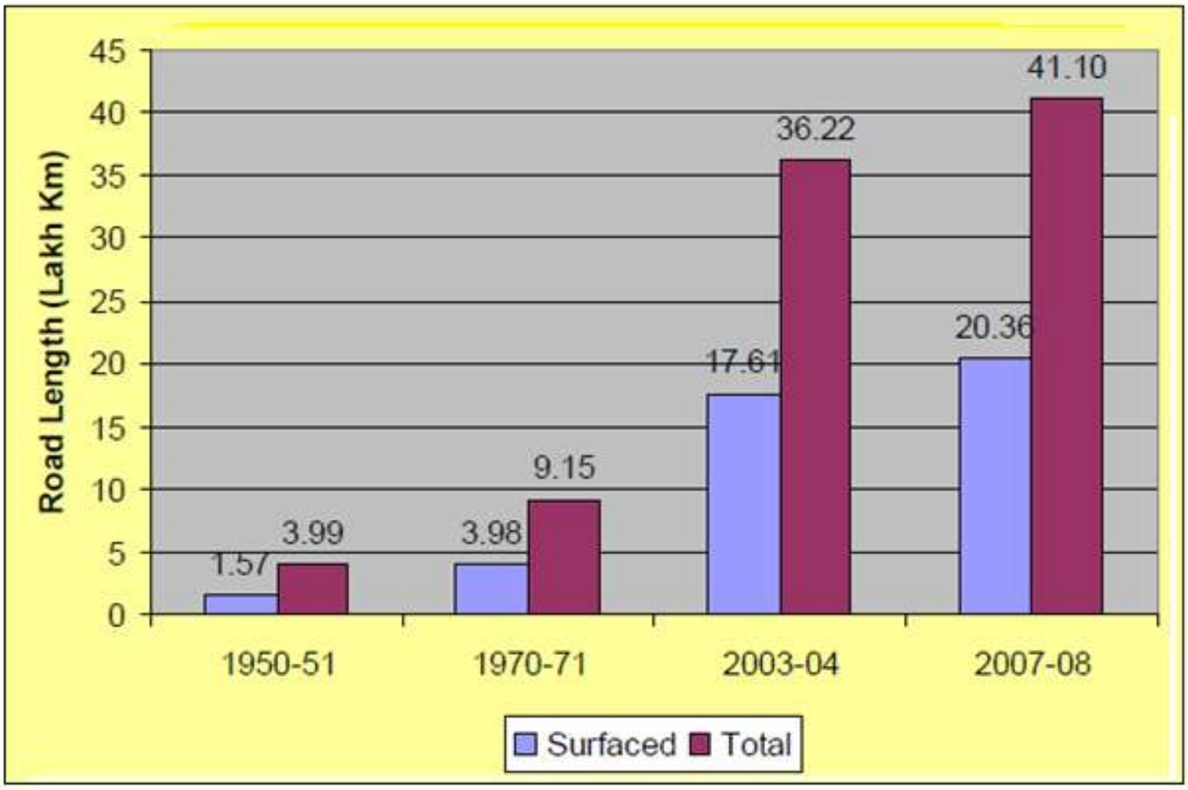

Figure 1: Total & Surfaced Road Length (1950-51 to 2007-08)

Category wise Growth in Roads

As seen from the Table 1, the total surfaced road length grew from 3, 97,948 km (accounting for 43.5% of the total road length) in 1971 to 20,36,063 km (accounting for 49.5 % of the total road length) in 2008 reflecting a more than fivefold increase in surfaced road length. Category wise classification of road length showed that during this period, the length of National Highways (NHs) increased from 23,838 km to 66,754 km – an increase of over 180 % or CAGR of 2.8 %. During the same period, the length of State Highways (SHs) increased from 56,765 km to 1, 54,522 km (an increase of over 172 % or CAGR of 2.7 %) and the length of Other PWD roads increased from 2,76,833 km in 1971 to 8,63,241 km in 2008 (an increase of about 212 % or CAGR of 3.1 %). Various categories of urban roads together expanded in length from 72,120 km to 3, 04,327 km reflecting an increase of over 322 % or CAGR of 3.97 %. The highest growth over these 37 years took place in respect of Rural Roads which increased from 3,54,530 km to 24,50,559 km (including 10,61,809 lakh km roads constructed under JRY & PMGSY)registering an increase of nearly 591 % and a CAGR of 5.4 %. The lowest growth, however, took place in the length of Project roads which increased from 1, 30,893 km in March 1971 to 2,70,189 km by March 2008 resulting in a growth of 106 % and a CAGR of 1.98 % only. The graphical representation of the growth trend of road length by category of roads between 1950-51 and 2007-08.

Expansion in Road network in terms of Broad Categories

The data compiled on road network can be broadly classified into five broad categories:

(1) National Highways (NHs)
(2) State Highways (SHs)
(3) Other PWDRoads
(4) Rural Roads
(5) Project Roads.

The National Highways, running across the length and breadth of the country, had a length of 66,754 km at the end of March 2008. National Highways comprise less than 2 per cent of the road network, but carry a high volume of the road-based traffic. State Highways (SHs) and Major District Roads (MDRs) constitute the secondary system of road transportation in the country. The State Highways connect National Highways, district headquarters, important towns, tourist locations and minor ports. The total length of State Highways is about 1,54,522 km. The remaining predominantly large segment of the total road network of about 3.89 million km is covered by the Other PWD Roads, Rural Roads and Project and Urban Roads. About 60 % of the total road length in India is accounted for by rural roads consisting of (i) Panchayat Raj Roads (about 33 %) i.e. Zilla Parishad roads, Village Panchayat Roads and Panchayat Samiti roads; and (ii) roads constructed under Jawahar Rojgar Yojna (JRY) and Pradhan Mantra Gram Sadak Yojana (PMGSY) accounting for a 26% share in rural roads. Roads constructed under the JRY (about 22 %) are of limited value from the point of view of movement of heavy traffic as only about 20 % of such roads are surfaced. The decadal figures of the road network under all these categories are provided in the Table 3. As would be seen from the table, the aggregate length of roads, which was 0.4 million km in 1950-51, had increased more than 10 fold to 4.11 million km by 2007-08.

Materials Used

The details about fly ash and the stabilizers used are described in the following sections:

Fly Ash

The fly ash had been collected from an electrolytic precipitator of Dadri thermal power plant. It is grey in color and consists of predominantly silty material. This fly ash is anthracitic class F fly ash and has low lime content. The grain size distribution, chemical composition and geotechnical properties of Dadri fly ash are given in Tables 8, 9 and 10 respectively.

Stabilizers

The stabilizers used in the study are ordinary portland cement and crumbed rubber. The sources of the stabilizers are given In Table 1.

Testing program

Unconfined compression tests were conducted on statically compared fly ash samples in stabilized and unstabilized form. The parameters included in the study are presented in Table 1. Daily records of the temperature humidity and rainfall are maintained for the entire curing period.

Table 1: Details of parameter of Dadri fly ash

Sr. No.	Type of curing & testing	Stabilizer (% by dry weight of fly ash)	Curing period (Days)	No. of samples
1	A	Cement 6%	7,14,28 & 150	4
2	A	Cement 6% & Rubber 5%	7,14,28 & 150	4
3	A	Cement 8%	7,14,28 & 150	4
4	A	Cement 8% & Rubber 5%	7,14,28 & 150	4
5	A	Cement 10%	7,14,28 & 150	4
6	A	Cement 10% & Rubber 5%	7,14,28 & 150	4
7	A	Cement 12%	7,14,28 & 150	4
8	A	Cement 12% & Rubber 5%	7,14,28 & 150	4

UNCONFINED COMPRESSION TESTS

The required quantities of fly ash and stabilizers, corresponding to dry unit weight requirement were calculated. An additional 2 grams of mixture was taken to compensate for losses during the preparation of samples. The total stabilizer content was kept constant as 4 percent of dry weight of fly ash. The fly ash and stabilizers were mixed together in a clean bowl in dry state, so as to have a uniform distribution of constituents in the mixture. Distilled water was added to the dry mixture as per the requirement of moulding water content and mixed well to form a homogeneous mixture.

The mixture was compacted in a cylindrical mould of 37.7 mm diameter and 73.5 mm long. Static compaction technique was adopted and compaction was done thrice alternatively from both ends of the mould to achieve uniform compaction. The sample was trimmed at both ends if required and extruded from the mould by using a hydraulic jack extruder.

The weight of the sample was measured in an electronic balance.

Methods of curing

Two methods of curing namely, laboratory curing and natural environment curing were adopted.

Laboratory curing

After preparation of the sample, it was kept in polythene bag and closed with a rubber band. Proper identification marks were made on the polythene bag using a permanent marker. The polythene bag was kept in a desiccator with water at the bottom and closed tightly with a lid. The desiccator was kept inside the temperature controlled room of the laboratory.

Natural Environment Curing

Samples were cured in open atmosphere to study the effect of temperature, humidity and rainfall on strength characteristics of stabilized fly ash. The samples were cured inside the laboratory for 7 days before placing them in the open environment. The samples were kept on the terrace of the building. The samples were restrained in position by surrounding them with hall pins on a termocole sheet. The samples were protected properly on all sides and at top to shield the samples from disturbance due to birds, etc.

Testing procedure

Unconfined compression test were conducted on stabilized and unsterilized fly ash samples using strain controlled triaxial testing machine. The deformation rate for laboratory cured and unsterilized fly ash was 0.4064 mm/min. In order to study the effect of immersion in water on strength, the laboratory cured samples were tested with and without immersion in water before the test.

Laboratory cured samples

After the required period of curing, the samples were removed from the polythene bags and weighed. They were tested in a strain controlled triaxial testing machine at a deformation rate of 0.4064 mm/min. The entire sample after the test was kept inside an oven for determination of water content.

Natural environment cured samples

Most samples were more or less dry when they were removed from open terrace after the curing period and in that state would have very high strength. In order to simulate the least favourable water content during testing, the samples were immersed in water for 6-8 hours before testing.

The weight of the samples was taken before immersion in water. The water on the surface of the samples was wiped gently using a filter paper. They were trimmed from both ends to have plane surface and the final length of the samples was measured. The diameter of the samples was unaffected by the impact of rainfall. The samples were weighed including the trimmed mixture to determine the loss of material due to erosion. Then the sample was tested in a triaxial testing machine with reduced deformation rate based on final length of the sample. The moisture content of the sample was determined after the test.

DISCUSSION OF RESULTS

Effect of density and moisture content on the UCS of stabilized fly ash

As in the case Of unsterilized Samples, in cement stabilization also, the higher density samples have a higher strength than the lower density samples at all stages of curing. However, the effect of water content is not significant. UCS of samples having 95% MDD but differing in water content by 6% tend to be nearly the Same after 120 days of curing.

The higher UCS of sample at MDD state is due to the combination of factors like the availability of more fly ash particles for pozzolanic reaction with stabilizer, more quantity of stabilizer and the formation of dense structure with less void spaces.

Effect of method of testing on the UCS of laboratory cured stabilized fly ash

The UCS of stabilized samples tested without immersion is generally more than the Up of similar samples tested after 6 hours of Immersion in water. In the case of cement stabilization, immersion causes significant reduction in strength beyond one week curing period.

The moulding water content has greater influence on the UCS if the samples are immersed in water before testing. The reduction in the UCS of 56 days cured samples compacted at (95% MDD, OMC +3%) is 21.5%. But for samples compacted at (95% MDD, OMC -3%) the UCS is more or less same for immersed and un-immersed samples.

Effect of method of curing on the UCS of stabilized fly ash

The variation of UCS with time for laboratory and naturally cured samples. All these samples were immersed in water 6-8 hours before the test. The moulding water content plays significant role on the UCS. For samples compacted at 95% MDD the UCS of the naturally cured samples is less than that of the laboratory cured samples prepared with moulding water content 3% more than OMC, the UCS of naturally cured samples is more than laboratory cured samples.

Effect of type of stabilizer and their combination on UCS of fly ash

Till about 56 days of curing, the UCS of cement stabilized fly ash is more than that of lime stabilized fly ash This trend is same for different combinations of density and moulding water content. However, the gain in UCS of lime stabilized samples increases rapidly after 56 days and at the end of 120 days the UCS of the cement and crumbed rubber stabilized samples are nearly equal. The reaction product is same (C-S-H jels) for both the stabilizers and probably the amount of reaction product due to the two stabilizers are nearly same after long period of curing.

Effect of curing period

The UCS of all stabilized fly ash increased with curing time irrespective of factors like variation in density and moulding water content, method of curing and testing adopted and type of stabilizers. They however, affected the time rate of increases in UCS and the maximum UCS that might be attained after long period of curing.

The strength gain is rapid for cement stabilized - laboratory cured - immersed and unimmersed samples. At 14 days the Up of cement stabilized fly ash was more than 50% of its 120 days UCS. The same trend holds good for naturally cured samples at MDD state. But the UCS of sample having 95% MDD decreased with curing time for the natural environment curing method. The samples having MDD were able to withstand the impact of environmental factors more than those having 95% MDD.

Table2: Readings after 7 days

	7 DAYS SAMPLE		F.A+C+CR			LOAD IN kg		
DDGR	C 12%	C 12% R 5%	C 10%	C 10% R 5%	C 8%	C 8% R 5%	C 6%	C 6% R 5%
0	0	0	0	0	0	0	0	0
10	11	6	5	1	10	7	9	4
20	25	12	14	4	22	14	15	6
30	42	21	25	8	43	26	28	9
40	63	31	43	13	69	40	48	16
50	91	40	66	19	101	54	66	26
60	127	49	94	26	136	63	84	35
70	163	66	123	33	177	79	98	45
80	208	85	152	40	205	88	109	52

90	250	103	171	48	232	94	121	58
100	282	122	195	61	251	96	129	62
110	315	137	221	74	266	98	134	64
120	342	150	254	89	275	99	139	66
130	371	160	244	103	214	99	108	68
140	392	164	193	113	197	98	97	69
150	408	159	128	125		95	89	69
160	95	152	90	137		90	87	69
170		146	58	147		83		64
180		132	41	154		74		55
190		73		159		68		38
200		32		158				
210		26		157				
220				153				
230				131				
240				109				
250				100				

CONCLUSION

The conclusion of the experimental study is presented in this chapter. The scope for future is also identified at the end.

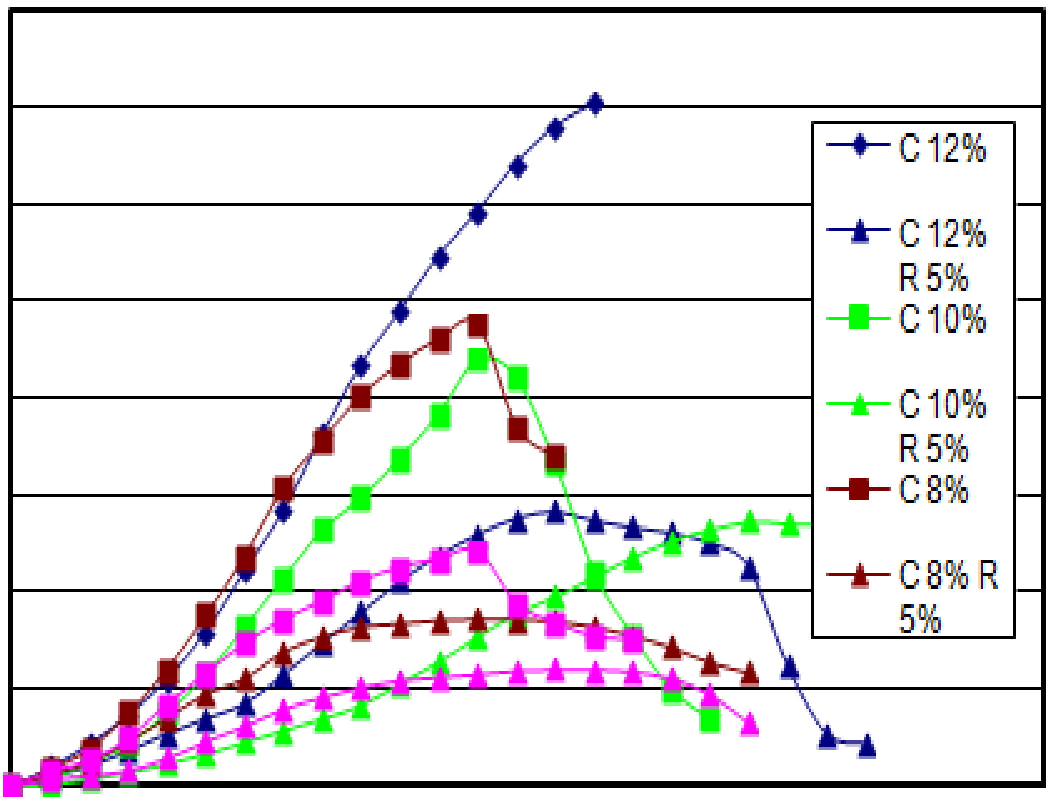

Fig. 2: Conclusion of the Experiments

SCOPE FOR FUTURE RESEARCH WORK

The following studies are suggested to be carried out to understand more about the strength behavior of stabilized fly ash.

1. Study about pozzolanicity of fly ash
2. Study of morphology and mineralogy of fly ash in stabilized and unstabilized forms.
3. The effect of various stabilizers in different proportions and combinations on the UCS.
4. The effect of stabilizers on the UCS of fly ash - soil mixtures.
5. The effect of inclusion of fibers on the strength behavior of stabilized fly ash - soil mixtures.
6. The effect of variation in water content and density on strength of stabilized fly ash – soil mixtures.
7. The effect of variation in deformation rate on the UCS of stabilized fly ash - soil mixtures.

8 The effect of method of curing on the UCS of stabilized fly ash - soil mixtures.

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